2007 Prize of Director General of Regional Bureau of Economy, Trade and Industry

Energy Conservation through Renewal of Chiller

Iwate Toshiba Electronics Co., Ltd.
Production Planning Department, Engineering and Environment Services
Section of Energy Conservation Promotion for Heat Source Facilities, Working Group

◎ Keywords: "Rationalization of heating, cooling and heat transmission" (Air-conditioning/hot-water-supplying equipment)

◎ Outline of Theme

Although we possess chillers producing cold water for air conditioning, 'total abolishment of emanating specific chlorofluorocarbons (CFCs)' and 'countermeasures for the energy loss by equipment deterioration' are our major issues. Aiming at solving these problems, we had been renewing total 7 machines step by step.
In conjunction with the machine renewal, we have undertaken additional measures including 'strengthening of water quality control', 'reduction of pressure loss in the piping' and 'improvement of equipment operation efficiency,' for realizing drastic reduction of energy consumption.

◎ Implementation period for the said Example

Ongoing as of February, 2007

- Planning period: June, 2005 ~ March, 2007 (22 months in all)
- Implementation period: February, 2006 ~ June, 2007 (17 months in all)
- Effect verification period: March, 2006 ~ July, 2007 (16 months in all)

◎ Outline of the business establishment

- Production items: System LSI (incl. CMOS sensor, LCD driver and Power-MOS)
- Number of employees: 1,860
- Energy quantity used annually (actual performance in FY2006):

[Electric power]	284,912 MWh/yr.
[Fuel oil A]	11,648 KL/yr.

◎ Target Facility

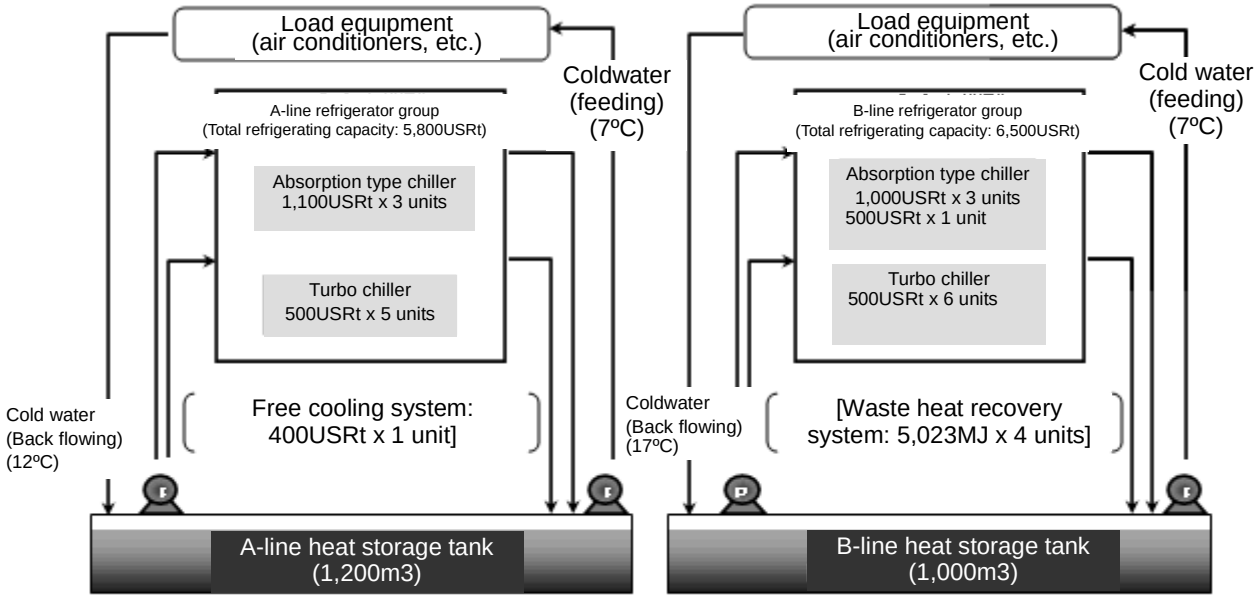


Figure 1 Outline of refrigerator facilities

1. Reasons for Theme Selection

- Reduction of energy (CO_2) and cost is our important task.
- Abolition of the chillers utilizing specific chlorofluorocarbons (CFC)
- Since many units of our chillers have been operating for more than 20 years, their deterioration is causing an extreme decrease of energy efficiency.

2. Understanding and Analysis of Current Situation

(1) Understanding of Current Situation

The total number of chiller units concerned is 18 units (turbo type x 11, absorption type x 7), of which 9 units have been operating for the past 20 years or over. Because of their deterioration, the problem of energy loss is arising. Additionally, many of our turbo chiller units utilize the specific chlorofluorocarbons (CFC-11) as working medium, so it is an urgent issue to take appropriate measures from the environmental aspect. Furthermore, the cold water produced by refrigerators is separated into two lines (A/B) through respective heat storage tanks and is supplied to the respective load equipment.

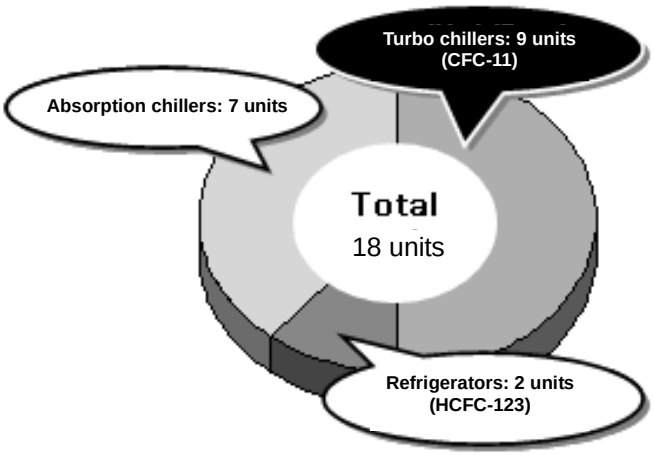


Figure 2 Composition of the chiller used in our facility

[Table 1] A-line chiller group – Capacity by Serial No.

	System	Serial No.	Capacity
A-line	Hydrodynami	R-1	500 USRt
		R-2	500 USRt
		R-3	500 USRt
		R-18	500 USRt
		R-19	500 USRt
	Absorption	R-11	1,100 USRt
		R-12	1,100 USRt
		R-13	1,100 USRt

Specific chlorofluorocarbons

[Table 2] B-line chiller group – Capacity by Serial No.

	System	Serial No.	Capacity
B-line	Hydrodynamic	R-4	500 USRt
		R-5	500 USRt
		R-6	500 USRt
		R-7	500 USRt
		R-8	500 USRt
		R-9	500 USRt
	Absorption	R-14	1,000 USRt
		R-15	1,000 USRt
		R-16	1,000 USRt
		R-17	500 USRt

Specific chlorofluorocarbons

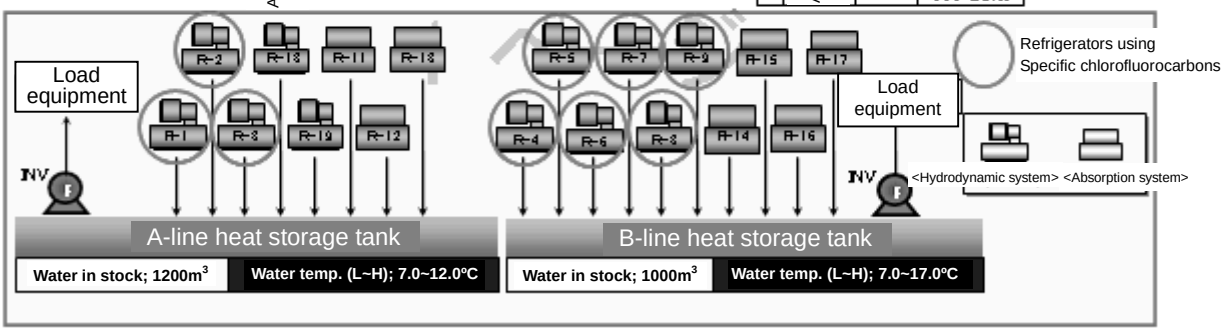


Figure 3 Outline of refrigerating facilities

(2) Analysis of Current Situation

1) Percentage of energy use in our factory

The Pareto diagram concerning the energy consumed by power facilities is shown in Fig.4. By application the category of air conditioning (46.2%) is the highest consumption of energy, and that of chillers (19.3%) follows it in the second place. In fact, 65.5% of the total amount is occupied by these two categories only.

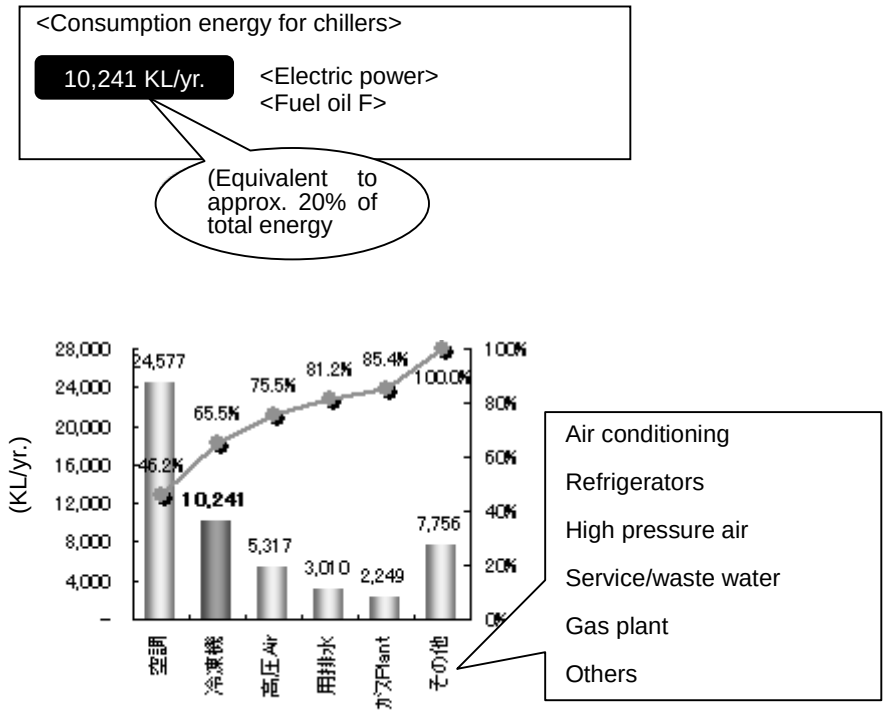


Figure 4 Energy consumption rate (Pareto diagram)

2) Survey on chiller capacity

Here are survey results of the chiller performance by each serial No.
The ‘actual capacity’ compared with that of ‘rated’ is shown in [Figure 5], while the coldwater production intensity (※), in [Figure 6]. Based on this result, we formulated the renewal plan of chiller by taking cost performance, space efficiency, and etc. into consideration. ([Table 3])

(※):Coldwater production intensity — An index as respects the operation cost per unit capacity, assuming the most efficient serial No. (R-6) machine as [1.0]

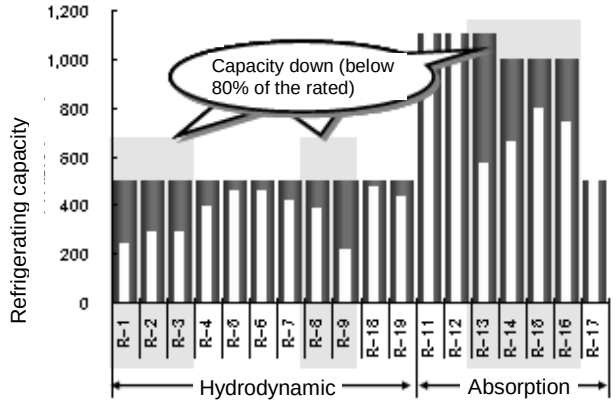


Figure 5 Chiller capacities by each serial No.

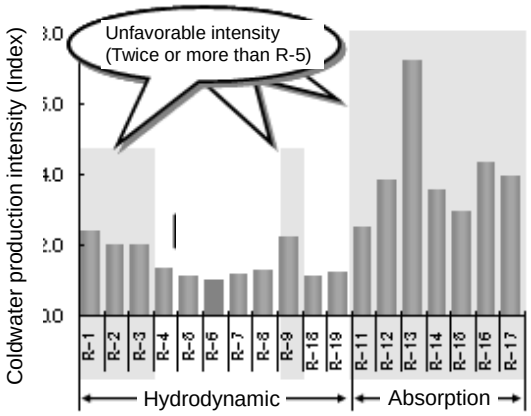


Figure 6 Coldwater production intensities by each serial No.

Table 3 Medium term renewal plan for chiller

	Model	Serial No	Installed in (FY)	Cooling medium	'04	'05	'06	'07	'08	'09	'10
Hydrodynamic	R-1	1984	CFC-11			●					
	R-2	1984	CFC-11								
	R-3	1985	CFC-11				●				
	R-4	1989	CFC-11					○			
	R-5	1989	CFC-11								
	R-6	1989	CFC-11								
	R-7	1989	CFC-11								
	R-8	1989	CFC-11								
	R-9	1989	CFC-11								
	R-18	1994	HCFC-123								
	R-19	1994	HCFC-123								
Absorption	R-11	2004	-		●						
	R-12	2005	-		●						
	R-13	1985	-				●				
	R-14	1989	-						○		
	R-15	1989	-							○	
	R-16	1991	-								○
	R-17	1991	-								○
	Units renewed				2	1	2	1	1	1	2

Total 7 units only selected for this plan (FY2005~2006)

Refrigerators utilizing specific CFCs (8 units in all)

<Explanatory notes>
●Already renewed
○To be renewed

Total 4 units of absorption markedly deteriorated

3. Progress of Activities

(1) Implementation Structure

The energy conservation promotion staff in Production Planning Department, Engineering and Environment Services in our company had been playing a central role in going ahead with this activity.

(2) Target Settings

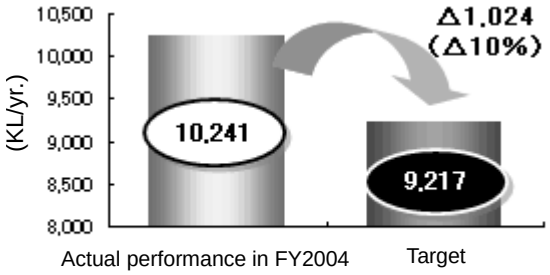


Figure 7 Energy reduction target

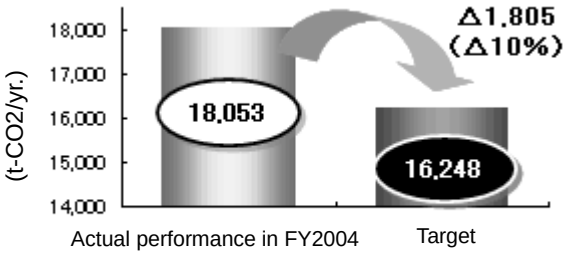


Figure 8 Target of CO_2 emission reduction

(3) Problem Points and their Investigation

1 Possession of those chillers which utilize a specific chlorofluorocarbon (CFC-11)

2 Deterioration of cold water production intensity due to aging of related equipments, etc

◆ Replacement with those highly efficient turbo utilizing alternative CFC

4. Details of measures

(1) Outline and implementation period of measures

[1] Constant-speed turbo chillers (specific CFC) ⇒ Renewal with inverter-controlled turbo chillers (alternative CFC)

a) A-line refrigerators No.R-1~3: 500USRt x 3 units ⇒ Put together into '1,250USRt x 1 unit'; Completed in February, 2006
- Change of slime retardant to be added to condenser cooling water (Trouble occurred after the start ⇒ Remedied later)

b) B-line refrigerators No.R-4~6: 500USRt x 3 units ⇒ Put together into '1,250USRt x 1 unit'; Completed in February, 2007
- Refrigerator's piping pressure loss improved ⇒ Aiming at downsizing the coldwater/cooling water pumps

[2] Absorption chiller ⇒ Renewal with inverter-controlled turbo chiller (alternative CFC)

A-line refrigerator No.R-13: 1,100USRt (absorption x 1 unit) ⇒ 1,250USRt (CFC x 1 unit); Completed in February, 2007
- Refrigerator's piping pressure loss improved ⇒ Aiming at downsizing the cold water/cooling water pumps

[3] Energy consumption reduction by promoting more effective use of A-line chiller

Production of B-line cold water by applying A-line chillers No.R-12, 28, 19; Realized in June 2007
- Aiming at energy consumption reduction by making effective use of the renewed A-line machine group

(2) Implementation of measures

1) Constant-speed turbo chillers (specific CFC) ⇒ Renewal with inverter-controlled chillers (alternative CFC)

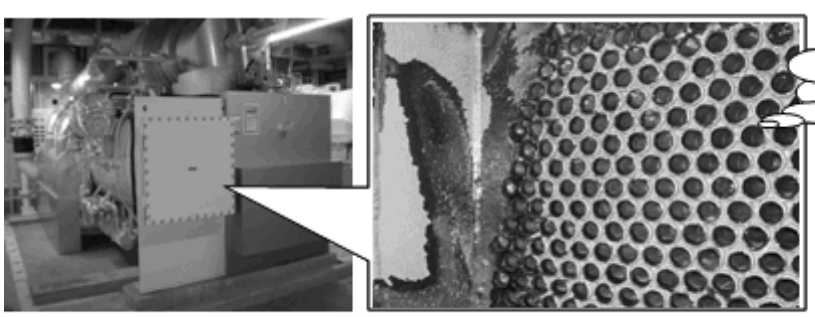
a)-1 Renewal of A-line chillers (Serial Nos. R-1~3)

As regards the model selection, we selected an inverter-controlled chiller which utilizes a cooling medium (HFC-245fa) the least in terms of environmental load and surpasses in partial load characteristics. Besides, the capacity was fixed on 1,250USRt as a result of taking 'cold water load balance', 'space efficiency', etc. into consideration. Further, a similar thinking was applied to the selection of additional machines (from the 4th unit onward) as well. The effect by this renewal proved annual reduction of △2,639USRt.

a)-2 Replacement of slime retardant (to be added to condenser cooling water) with another agent

The new chiller (1,250USRt; conventional 3 units put together into a single unit) started operation in February 2006, however, in three months of use, the machine ran down

because of the “higher pressure of condensed cooling medium”. We checked and found that the trouble had been caused by adhesion of a large amount of slime because of the unfavorable condition within the tubes, cooling water’s LTD※ (Leaving Temperature Difference), etc. (Figures 9, 10.) It was also noticed that the deformation of the fin shape in tube might have influenced greatly. After the obstruction was removed, the slime retardant of organic nitrogen type was replaced to that of inorganic chlorine type. As a result, the machine has been operating as of today without problem. Additionally, the similar water treatment had been given to the chillers from the 2nd unit onward as well, and they still maintain favorable operation.



LTD (Leaving Temperature Difference)
Deviation value between the temperature of the refrigerator’s condensed cooling medium and that the outlet temperature of the cooling water:
This value serves as an index to know the degree of condenser’s dirtiness, in other words, the dirtier the heat exchanger gets, the more the deviation value rises.

Figure 9 Slime adhered to the chiller

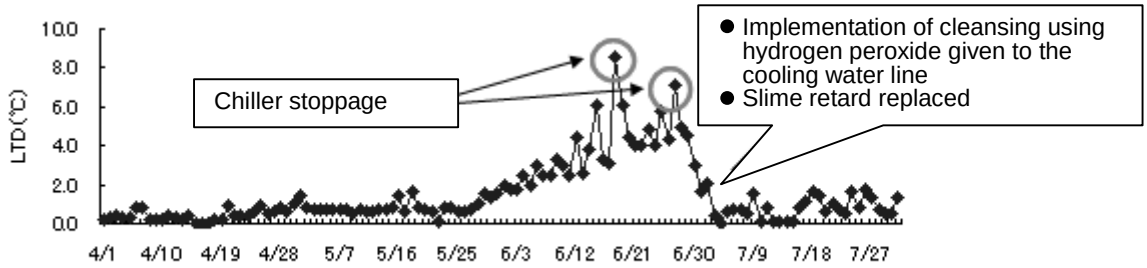


Figure 10 LTD transition

b) Measures against the chiller’s piping pressure loss (Reduction of the water line’s piping flow resistance loss, from examination to implementation)

On the occasion of integrally renewing the 4th~6th machines, we decided to reduce the pump’s electric power by means of improving the pressure loss in the cold/cooling water piping. Valve, strainer and one-way valve might cause flow resistance and their number was limited to the minimum necessary so that they might not become an obstacle to the refrigerator’s normal operation. Further, we adopted the joints with the less resistance. Consequently, it has become possible to downsize cold water pumps from 55kW down to 45kW, i.e. 10kW saving, and cooling water pumps from 90kW to 75kW, i.e. 15kW saving. As compared to our traditional execution of works, we have succeeded in eliminating four gate

valves, three strainers and one one-way valve when assembling one unit of chiller (Figure 11.) In addition, for future renewal of chiller, we decide to follow the same approach.

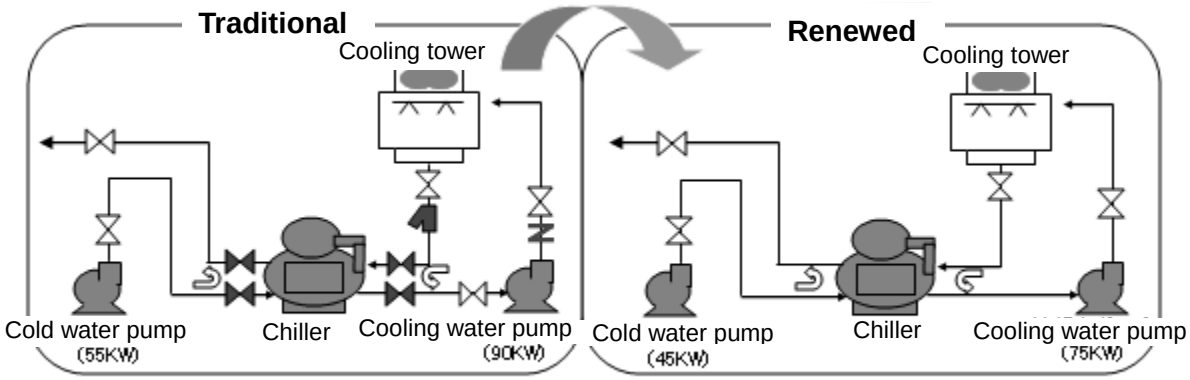


Figure.11 Refrigerator flow chart in outline

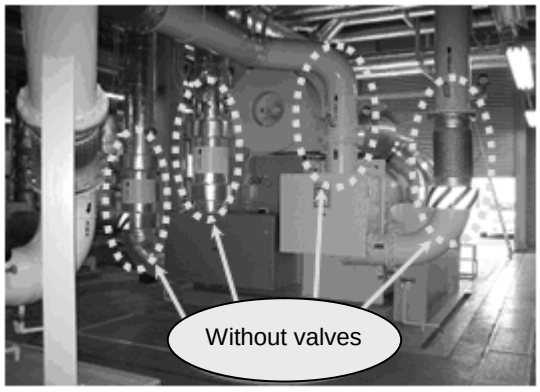


Figure 12 Example of peripheral devices of chiller

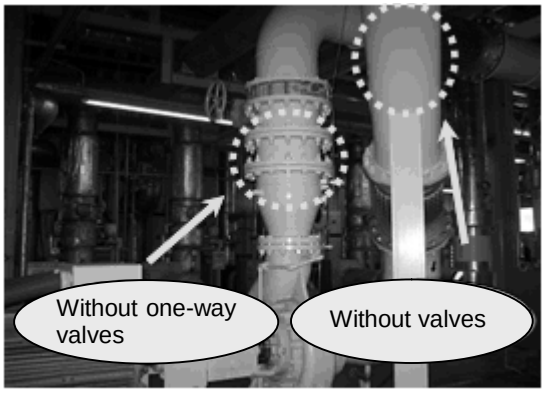
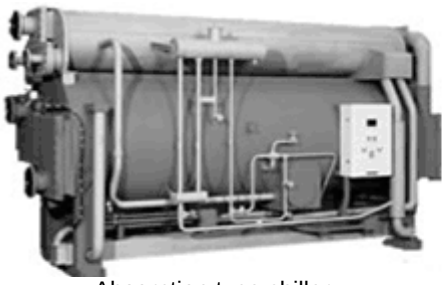


Figure 13 Example of peripheral devices of cooling pump

2) Absorption type chiller ⇒ Renewal with inverter-controlled turbo chiller (alternative CFC)

We had been possessed quite a few absorption type chiller for the purpose of maintaining the form of a cut-rate electric power contract. However, by dint of adopting a new reform measure (such as our reconsideration given already on the chiller's operation mode), we could come to shift from the operation by traditional unit to that mainly by new turbo machine. In other words, the absorption type machine whose specific unit of cold water production had been lowering remarkably, resulted in being replaced by a new inverter-controlled chiller (w/1,250USRt capacity) , thus allowing for the annual energy reduction of 65MWh for electric power and 329kL for fuel oil.



Absorption type chiller
(1,100USRt)

Figure 14 Absorption type chiller

Inverter turbo chiller
(1,250USRt)

Figure 15 Inverter turbo chiller

3) Energy reduction by promoting more effective use of A-line chillers

Our chiller renewal plan in the A-line chiller group, was completed by “three units of hydrodynamic refrigerator (each 500USRt) renewed integrally with one unit (250USRt),” as well as by renewing one unit of traditional absorption type machine with one unit of turbo machine (1,240USRt,). Thus we could largely improve the specific unit of cold water production. (Figure.16.)※ In reference with the B-line chiller group, however, we are still in the transition period of renewal, besides, the B-group machines are less favorable in terms of the coldwater production intensity as compared to the A-line units. Accordingly, for the purpose of realizing more effective application of A-line refrigerator group, a new piping system was arranged so that the high temperature (17ºC) water within the B-line heat storage tank could be cooled by the A-line refrigerator group, and that the cooled water could be returned to the B-line tank (Figure 17.) This recycling operation already started and led to a comprehensive energy reduction since the annual consumption of fuel oil decreased by 272KL (although the annual electric power consumption increased by 242MWh.)

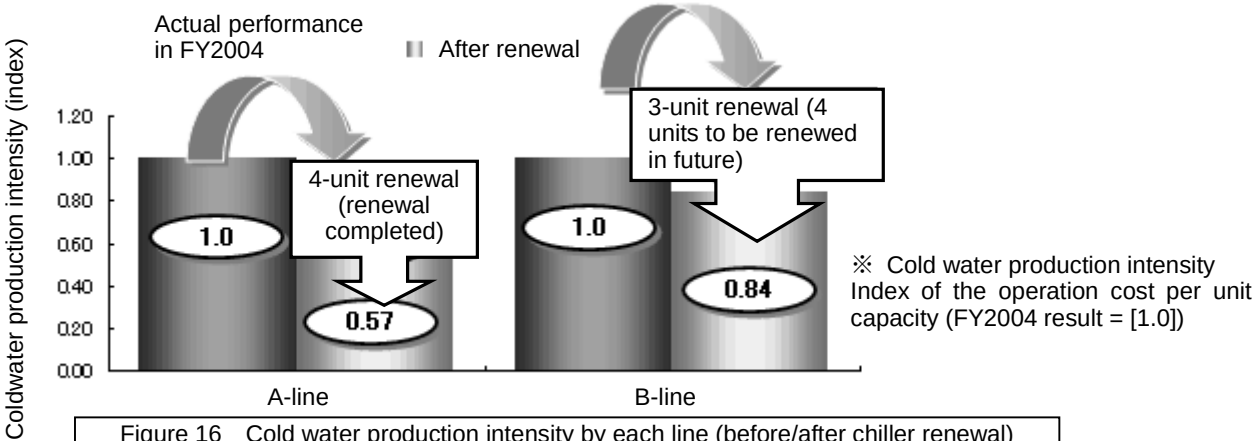


Figure 16 Cold water production intensity by each line (before/after chiller renewal)

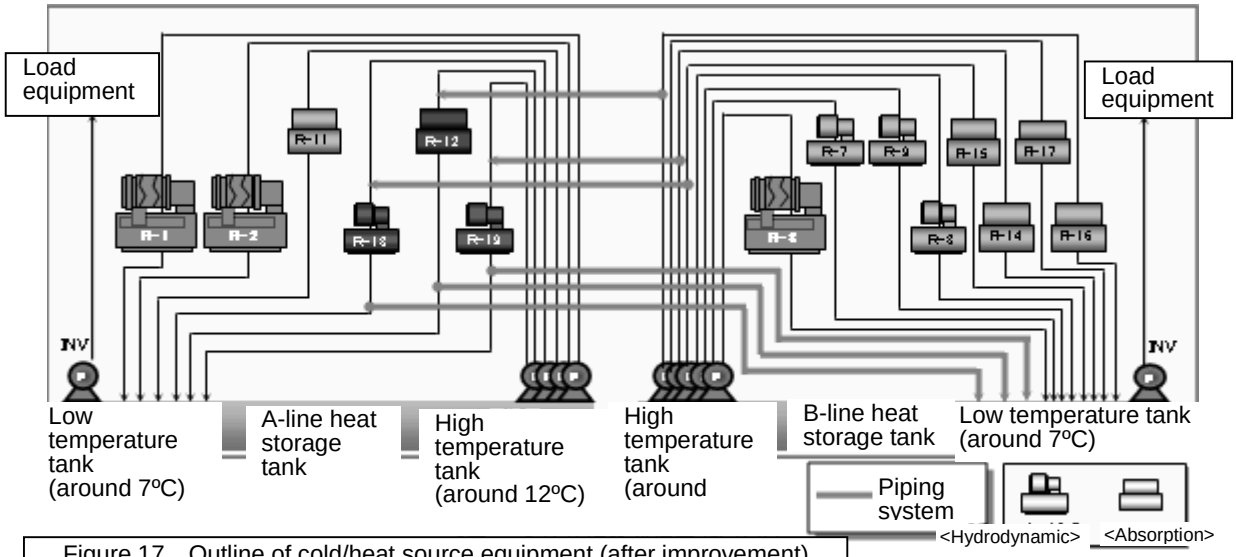


Figure 17 Outline of cold/heat source equipment (after improvement)

(3) Summary of the implementation

Content of implementation	Quantity of energy reduction	Effect (equivalent to fuel oil)
① **Renewal: Constant-speed turbo chiller Inverter-controlled turbo chiller a) A-line chillers (R-1, 2, 3) — Renewal b) B-line chillers (R-4, 5, 6) — Renewal & piping pressure loss improvement**	Electric power 2,639MWh/yr	△700KL/yr.
② Renewal: Absorption type chiller Inverter-controlled turbo chiller A-line chillers (R-13) renewal & piping pressure loss improvement	Electric power 65MWh/yr Fuel oil 329MWh/yr	△350KL/yr.
③ Energy reduction by effectively utilizing A-line chiller group B-line coldwater production helped by A-line chillers (R-12, 18, 19)	Electric power +242MWh/yr Fuel oil 271MWh/yr	△209KL/yr.

Energy scaling ratio
Electric power; 0.265L/KW, Fuel oil; 271.01KL/KL

5. Effects achieved after Implementing Measures

Energy consumption of chillers

Energy reduction effect (equivalent to fuel oil)

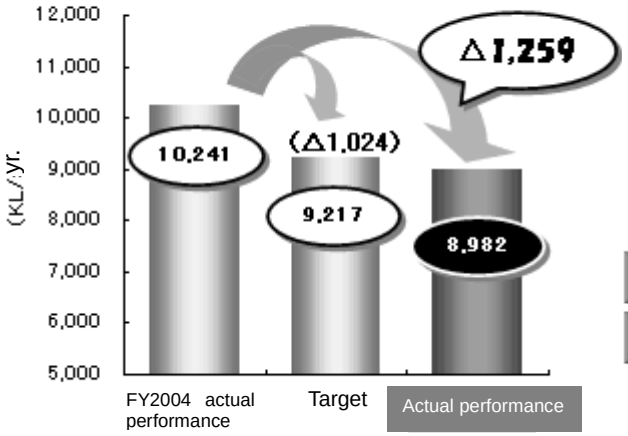


Figure. 18 Effect of Energy reduction

The effects obtained by chiller renewal and further energy conservation measures are shown in Fig. 18. The initial target was set at the 1,024KL/yr. (equivalent to 10% of the energy concerned) reduction, but in consequence, we succeeded in obtaining an over 23% energy conservation effect (1.259KL/yr).

Electric power	28,135 ⇒ 25,674 MWh/yr
Fuel oil A	2,758 ⇒ 2,158 KL/yr

Reduction effect of CO_2 emission

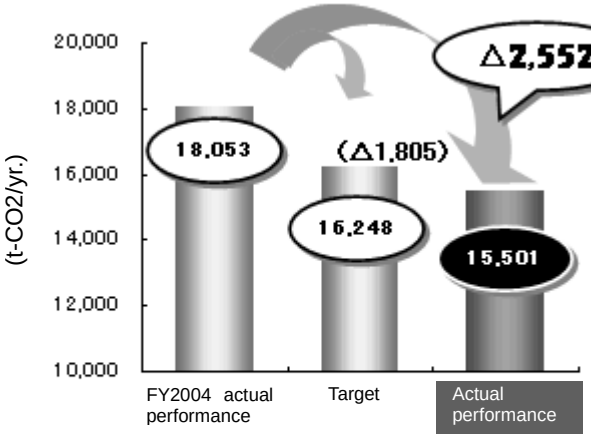


Figure 19. Reduction effect of CO_2 emission

CO2 emission
Electric power; 0.376t-CO_2/MWh, Fuel oil; 2.71t-CO_2/KL

Cost reduction effect

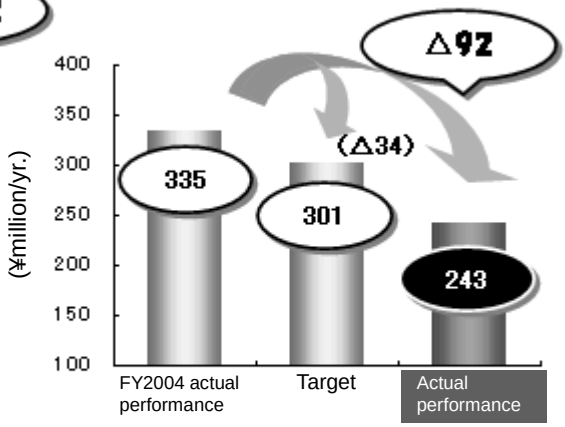


Figure 20. Cost reduction effect

Effect in all

As a result of various measures described above, we could obtain a favorable effect exceeded our target in each item.

Concerning the cost-related matters as well, the results surpassed the target on a large scale, additionally helped by the price up-trend of fuel oil A in connection with the worldwide steep rise of fuel oil.

Table 4. Effect in all

	2004 Actual performance	Target	Actual performanc	vs. 2004 actual performance
<Chiller consumption energy> (KL/yr.)	10,241	9,217	8,982	△1,259
<Ciller CO_2 emission> (t-CO_2/yr.)	18,053	16,248	15,501	△2,552
<Chiller operation cost> (¥million/yr.)	335	301	243	△92

6. Summary

With a view to abolish specific CFC totally and to improve energy loss resulted from machine aging, we had planned to replace 7 units of traditional refrigerating machines with 3 new units in an integrated manner, and actually implemented this renewal as planned. In conjunction with chiller renewal, we also took various measures including: “More stabilized chiller operation by replacing the chemical used for cooling water treatment (while making good use of our experience for trouble)”, “pump downsizing by reducing the quantity of the pipeline’s valves/joints, etc. (reduction of pressure loss)”, and “effective utilization of efficient refrigerator group”. All of these efforts produced significant results.

7. Future Plans

Although we succeeded in reducing CO_2 emission thanks to various measures earlier mentioned in this report, we still possess specific-CCF based chillers as well as a number of equipment which have become too old for work. Under these circumstances, we would like to carry out the following items deliberately, while making greater efforts for reduction of energy (CO_2) and cost.